Fluvial Processes in Geomorphology

Luna B. Leopold

M. Gordon Wolman

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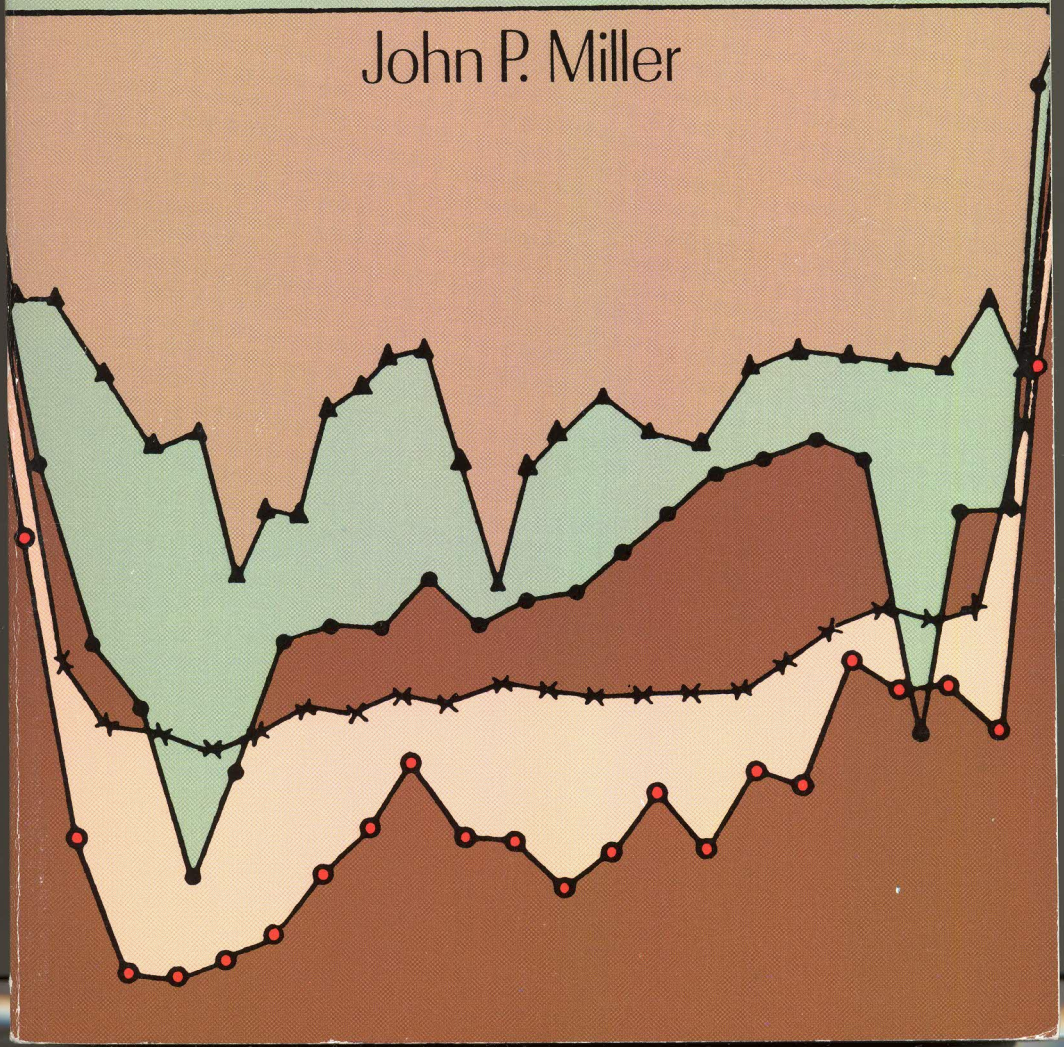

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To Carolyn, Elaine, and Laura

in 30 or 40 years. In the same river basin in Sioux County, Nebraska, a cottonwood tree approximately 60 years old was found buried by 8 feet of alluvium, and in the same period subsequent cutting eroded a channel slightly below the original roots of the tree (Schumm and Hadley, 1957, p. 170). Historical records, of course, provide unparalleled data on aggradation—if the record can be read. Classic among these is the record of the Nile, which had been building up its bed and flood plain at a rate of about 0.03 foot per year in the vicinity of Karnak and Memphis (Lyons, 1906, pp. 315–317). This rate is measurable only because gages, temples, and statuary provide a record of thousands of years. It may at first glance seem slow, but it is $\frac{1}{6}$ the rate of accumulation represented by the generations of fence posts, a rate which is considered rapid.

Like the Nile, the Tigris-Euphrates valley furnishes a record of irrigation agriculture extending back 6,000 years. The patterns of development at two different stages were worked out in detail and plotted on maps by Jacobsen and Adams (1958). Under both ancient and modern Mesopotamian conditions a clear distinction between canals and rivers is generally meaningless or impossible. Silt banks produced by cleaning canals are major topographic features; they extend for great distances and tower over all but the highest mounds marking the ruins of ancient towns and cities. Archeological soundings indicate an average accumulation of roughly 33 feet of silt in some alluvial areas during the last 5000 years. Values for the Indus River at Mohenjo-Daro are of the same order of magnitude. A part of this sediment in Mesopotamia is doubtless the result of severe floods, but much of it has come from cleaning canals and from sediment carried to the fields by irrigation waters. During the last 4500 years extension of the Mesopotamian delta has shifted the shore of the Persian Gulf approximately 180 miles to the southeast, a rate of delta building considerably greater than the present figure of 1 mile in 70 years. The degree of human influence on this process cannot be precisely defined.

There are cases, of course, where the degree of human influence is overriding. Man's activities have not been considered separately, however, because as a rule the geomorphic effects produced by man are the same as those produced without him. Usually man simply changes the magnitude of certain variables in the system. These in turn produce responses, perhaps only acceleration or deceleration, in the fundamental geomorphic processes. The appropriate principles are not abrogated. Not infrequently these principles are best illustrated where man has had a hand in molding the result.

The history of hydraulic mining in the Sierra Nevada, California, not only illustrates the effect of man on the landforms of a region but also provides a good example of aggradation as a result of increasing sediment yield without compensating increases in flow. In the early days of the gold rush only a small amount of dirt was disturbed, as most of the work was done by laborers with pick and shovel. As more efficient methods were developed, water power was substituted for manpower and vast quantities of earth were handled in separating the gold from the placer deposits in which it was found. Hydraulic mining increased steadily until 1884, when a series of injunctions brought by residents of downstream areas halted the entire operation. At the height of hydraulic mining it is estimated that scores of millions of cubic yards of earth were moved each year. Apart from the considerable topographic changes rendered directly by the mining, the principal effects were those on the streams, which resulted from overloading with detritus and led to extensive aggradation over broad areas.

The general trend of such deposition is shown by the graphs of low-water records of the Yuba River at Marysville and the Sacramento River at Sacramento (Fig. 11-1) in the period 1849–1913. Gilbert (1917, pp. 46, 50) estimated that 2,375,000,000 cubic yards of sediment were moved

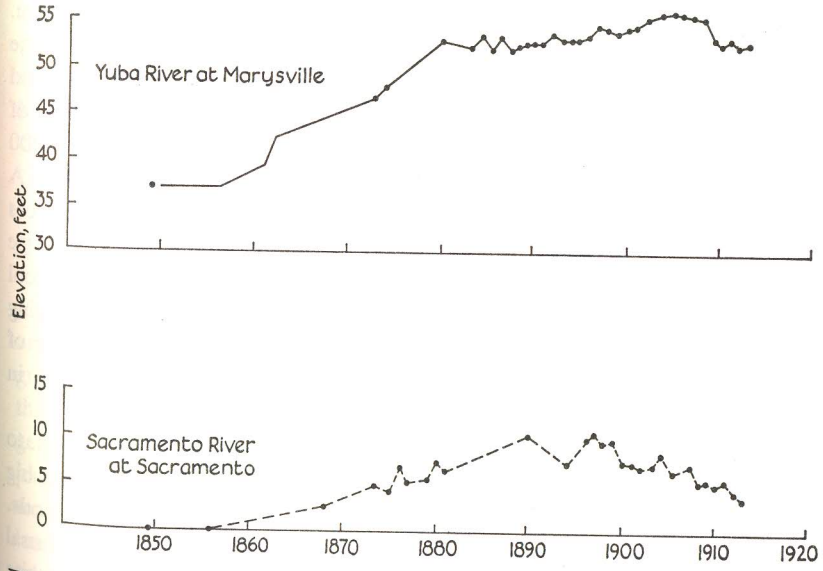

Figure 11-1. *Fluctuations of low-water level due mainly to deposition of mining debris on stream beds [After Gilbert, 1913.]*